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SCIENCE AND THE SCIENTIFIC ATTITUDE[1]

By Professor ROBERT S. MULLIKEN

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IN my old home town on the coast of Massachusetts there lived some hundred or hundred and fifty years ago a gentleman who styled himself Lord Timothy Dexter. This self-dubbed nobleman was noted for several exploits, of which I will mention three. Lord Timothy once shipped a cargo of warming pans to the West Indies. This seemed rather a joke to his fellow-townsmen, but, as it happened, the warming pans turned out to be ideal for boiling down sugar-cane juice, and Lord Timothy made his fortune there and then. On a later occasion, this gentleman, fearing that his wife did not love him, pretended to be dead. When she failed to weep at his funeral, he jumped out of the coffin and beat her soundly. Finally, Lord Timothy once wrote a small treatise, entitled "A Pickle for the Knowing Ones." He could spell after a fashion, but he could not punctuate. So, in his text, he put one word right after another, but at the end he included a page of periods, commas and semicolons, with the invitation to his readers to "peper and solt it as they plese." In similar fashion, I come to you now with a discourse that is unseasoned by humor; but I beg you to pepper and salt it to suit your own respective tastes.

Although Lord Timothy was not, strictly speaking, a scientist, he had something of the scientist's experimental and obstinately non-conforming spirit. I think, therefore, that he would not object that I am using him to introduce a speech on science and the scientific attitude. I shall begin with a definition.

The word "science" is derived from the Latin "scientia," which can be translated, roughly, as "knowledge." Present-day science may be defined briefly as *organized* knowledge. More fully, it may

[1] Speech "for the faculty" at trustees' dinner to faculty, University of Chicago, on April 9, 1937.

be described as knowledge found by experiments or observations and organized by rigorous logic under the drive of creative imagination. (In the development of science, the finding and organizing processes continually act and react on each other.)

In my remarks to-night, I should like not so much to emphasize the technique or subject-matter or the well-known material triumphs of science, but rather the scientific attitude, that is, the habit of mind and will characteristic of scientists. Especially I should like to express belief in the great potential value of this attitude for human welfare, including the proper development of education.

The trouble with the world to-day, most scientists believe, is not that there is too much science, but rather that the scientific attitude—the essence of science—is far too little understood and too inadequately applied to human problems. Even among scientists themselves, outside their own specialties, the scientific attitude is far too rare and is never fully developed. Now, you ask, just what *is* this scientific attitude? Briefly, it is an attitude in which supreme value is attached to the idea of objective truth. But science has learned from experience the very great difficulty of finding and of knowing truth and the extreme likelihood of error. Therefore, it combines with its faith a most thoroughgoing skepticism and a tremendous patience and open-mindedness. Dogmatism and wishful thinking are abhorrent to it. Finally, a sense of humor is a useful accompaniment if not a necessary ingredient of the scientific attitude, which otherwise would impose an intolerable strain on human nature.

I should like now to sketch in one or two salient features of the general picture of science and the scientists. Characteristic of science, and at least in part of philosophy too, is a never-ending striving toward a perfection of understanding which, so far at any rate, paradoxically seems to grow more remote as it is approached. Because of this, there becomes imbued in the scientist a willingness to accept science as tentative, ever-changing and always imperfect. This continual striving in the midst of uncertainty runs contrary to the normal human desire for secure knowledge. Yet, for better or for worse, it apparently corresponds to the true nature of life.

Indeed, it is not only professional scientists and philosophers who have felt the futility of being too impatient to solve the riddle of the universe. Thus the poet Keats refers to Shakespeare as a man who was "capable of being in uncertainties, mysteries, doubts, without any irritable reaching after fact and reason." To be sure, the restless striving after new scientific truth seems to be excluded here; but at the same time, the possibility of contentment with imperfect knowledge is well expressed.

There is no doubt that science has changed human ideas very much, and in particular has brought many formerly accepted verities into the rôle of illusions. Frequently it has banished both spirits and hobgoblins together, and, it must be confessed, it has tended thereby to give a certain flatness to things. But after all, if these *were* illusions, that is, if they could not be defended against science, we can not say that science here has destroyed any tangible reality, any objective truth. On the other hand, there are many ideas which the scientist may be inclined to classify as illusions, but to which one must grant at least subjective or poetic or psychological truth. If such ideas or illusions have value for us, it is entirely sensible and scientific that we should keep them, and even that we should search for more and better ones. After all, the pursuit of admitted illusions is nothing new. Illusion is vital in the art of the theater and in many other arts.

In the main, the scientific attitude is much the same as the intellectual attitude. It is a mental condition, never completely realized in practice, in which the feelings and emotions are encouraged to help, but not allowed to interfere, with logical thinking. Because of this necessity of holding the emotions in check, and more especially for other less direct reasons, the scientific attitude has had a tendency to discourage emotional and esthetic expression. In particular, industrial mass production, based on scientific discovery, has acted adversely on individual artistic expression in everyday life.

This, however, does not mean that thinking and its daughter, science, are inherently pernicious. It means, rather, that they have become too one-sided in our Occidental civilization, neglecting the emotional part of human nature. It is now time to see what we can do toward remedying this oversight. Indeed, much has already been done in some countries toward restoring the balance between esthetic and material development; and there is much here that we could learn from the Orient. The hard-boiled scientific attitude is inherently quite capable of seeing and objectively investigating the need of human beings for esthetic and emotional expression. Such research would come under psychology and related subjects. To the best of my knowledge, these sciences are making good progress, even though they are still in infancy. In the light of the history of science, I see no reason why they may not eventually make as enormous contributions to the non-material side of the art of living as, for example, the physical sciences have to the material side, if they go about it in the right way.

But what *is* the right way for science to approach new or little-developed fields? It seems to me that it is primarily by bringing to bear the scientific attitude,

in its most general form, and not by trying to transplant special techniques from other fields. Aside from certain very general characteristics, we should be prepared to find that the appropriate techniques may vary enormously from one science to another; and of course they may also vary greatly with the degree of maturity of the science. Undoubtedly, in many instances, techniques similar to those of older sciences may turn out to be appropriate, but it would be unscientific dogmatism to assume this in advance.

Looking back over my own experience, I think it was in a course on quantitative chemical analysis that an appreciation of the scientific method and its rigors began really to take hold of me. Before that, I had been interested in the wonders of science in an irresponsible and second-hand sort of way. But in quantitative analysis, which, by the way, I detested, I was brought face to face with the unpitying relentlessness of nature, in the form of some brute facts of chemical technique. Slipshod work wouldn't do. There were no short cuts to beat clear thinking, careful technique and endless patience. Later on, I found that the same unnatural methods are always required in those activities commonly called "research." Indeed, these same methods are also taught by many forms of human experience and have value in all successful activities. But I believe that these types of behavior, and especially certain further qualities which I will talk about in a moment, are encouraged with particular insistence by scientific work.

The primary objective of science, of course, is to try to find out what *nature* is really like: that is, to distinguish the *actual* universe, including mankind, from all the numberless forms the universe might conceivably have taken. In scientific research, man is engaged in a game with nature. Nature plays this game with a poker face and a certain inexorable humor. Nature calls every bluff—sooner or later. Sometimes she does it directly, sometimes through the work of one's fellow scientists. The embryo scientist soon learns that bluffing is a sheer waste of time and energy in this game.

I think it is right here that we have the most valuable lesson of scientific experience for human welfare in general. In the long run, all human activities are part of a great game with nature, a game in which man makes nature yield the earth's goods to him. Yet men are continually spending a large part of their time in bluffing and fighting one another. Aside from its very real value as part of the fun and spice of life, this kind of activity largely represents time stolen from the game with nature. It results in a low average efficiency and standard of living for the human race as compared with what we could have if we were more scientific.

Let us now return to the scientist trying to discover nature's secrets. He soon finds that only the most persistent, rigorously honest and boldly imaginative effort can win. Nature plays the perfect Sphinx and is completely adamant to every clumsy attempt to force the locks that guard her secrets. Yet to the man who finds the correct combination for one of these, *i.e.*, the truth, she yields without the slightest resistance. Further, the devotee of science, that is, if I may change the metaphor, the man who woos nature for her secrets, must develop enormous *tolerance* in seeking for ideas which may *please* nature, and enormous patience, self-restraint and humility when his ideas over and over again are rejected by nature before he arrives at one to please her. When the scientist does finally find such an idea, there is often something very intimate in his feeling of communion with nature.

It is my belief that experiences such as these should have tremendous value for education, by teaching the scientific attitude or, in other words, the scientific virtues.

It may be that when I say "scientific virtues," many of you will want to substitute the expression "scholarly virtues" or "intellectual virtues." If so, I shall not quarrel with you. When I say scientific virtues, I am merely giving expression to my own outlook, based predominantly on experience in physical science. I leave it to you to judge to what extent the same virtues are common to all learning, or are taught by all experience, and to what extent they may be peculiar to science. Reciprocally, I concede the possibility of non-scientific virtues.

As regards the teaching of the scientific attitude, the first great question is, can it be done with large numbers of people or only with a few? By our usual authoritarian processes of elementary and general education, students commonly lose their native confidence in their own powers of observation and reasoning, and tend to believe only what they read or are told. They generally fail to realize that what they read or hear, in so far as it is true, is based on adventurous contacts of men with nature in the past.

We need, then, in education, as everywhere in the art of living, to revitalize the spirit of adventure, of inquiry and experiment, the spirit which underlies all creative effort. We need to show students how *really* to take part in the game with nature. We should incite them to learn that nature is real, that nature can be touched and can be dealt with, that nature can be made to help us but can not possibly be bluffed or bribed into doing so. Contact with nature, both physical and intellectual contact, but always vital and creative contact—it is into this that we should try to lead our students.

I shall not have time to deal extensively with the tremendous problem of how this can be done. The main essential seems to be that the student shall be

induced or trained to make his own contacts with nature, and to acquire skill in putting questions directly to nature and in getting answers which he can trust. Such questions may be put in the laboratory, in the arm-chair, in the studio, in the great outdoors or in the haunts of business and industry. The greater the variety of the scenes of action which the student can effectively explore, the broader and better founded should be his resulting generalizations. The scientific or the intellectual attitude comes into being through analytical and dispassionate study of such fields of action, with the help, of course, of thinkers of the past. My confidence in the feasibility of developing the scientific attitude by comparatively simple methods and in many people has recently been strengthened by a scientific colleague, who has told me of a successful experiment he once carried out by conducting an undergraduate course along novel lines of semi-research character.[2]

I should like now to go a little further in reviewing the scientific virtues and in giving some examples of their application. These virtues may conveniently be grouped under the headings of intellectual efficiency, honesty, courage and tolerance. Intellectual efficiency involves the wise use of logic and creative imagination. Honesty, imbued by the struggle with nature, carries with it such things as sincerity, mutual trust, loyalty to truth, impartiality and justice. All these latter characteristics are commonly found in the dealings of scientists with one another on scientific matters. Courage is essential, for a scientist can hardly bring back real prizes from his adventures without the courage of his convictions. Tolerance carries with it many things: respect for facts, including, of course, the facts of human nature; patience, forbearance, self-restraint, suspended judgment, a due humility as to the value of one's own judgment and opinions in relation to those of other people; and, finally, a demand for freedom.

I should like to develop this idea of freedom a little further, since it is a particularly vital one at the present day. Science demands freedom, freedom to conceive and test the most fantastic hypotheses if need be. In the universities, this takes the form of academic freedom, which has been so happily maintained at Chicago. Science, I think, is a natural ally of democracy, and *vice versa,* since democracy gives more freedom than other known forms of government. Science is opposed to repression, dictatorship and all varieties of patent-medicinism in government.

[2] R. W. Gerard, *Jour. Chem. Education,* 8: 1144, 1931. Of course this is not the only effort to introduce research methods into undergraduate work; on the contrary, undergraduate research courses have been provided for some years in certain institutions.

Science itself is by nature utterly conservative, in that it holds tenaciously to all ancient wisdom, so far as this remains true; yet at the same time it is utterly radical, in that it has no inhibitions about examining any new idea, however strange, provided this contains some promise of truth. Science is neither conservative nor radical as a matter of mere habit or sentiment, but only for real reasons. In a similar way, science combines extreme skepticism with a strong faith in its own powers, derived from its past achievements. In the adoption of new ideas, science normally proceeds by evolution, not by revolution; or if at rare intervals there is revolution, it is only through the bloodless triumph of convincing new facts or ideas.

Science, I have suggested, is a natural ally of democracy—more precisely, if I am not mistaken, of that variety known as Jeffersonian democracy. By this I mean a system whose first basic ideal is democracy of *opportunity,* for men and for ideas. This would seek to smooth out differences of opportunity caused by accidents of birth or origin, and it would encourage full and free development of men and their ideas. The second basic principle, really a logical corollary of the first, is an aristocratic one. Namely, since history and common experience show that men differ greatly in their capacities, it would freely concede relatively great opportunity and scope to the *best* men and their ideas; at the same time it would seek to minimize the twin evils of snobbism and class hatred. Roughly speaking, "best" would be estimated here in terms of the interests of the race as a whole. Some such ideal of democracy, it seems to me, springs naturally from the scientific attitude as applied to present-day circumstances; and I believe that a wider diffusion of the scientific attitude would tend to promote such an ideal.

In conclusion, what may we expect of science in the future? It would be unscientific to demand an explicit answer, but I think it is fairly safe to say that the actual future will differ greatly from the pictures of it by contemporary novelists. Scientific history tends toward the generalization that what we can most confidently expect is the unexpected; but further, that this unexpected always increases our power over nature. Since man is part of nature, it is not unreasonable to hope that through science we shall gradually gain increasing power to control the forces of human nature as well as of nature in general for the benefit of mankind. But we can hardly require science to *guarantee* this in advance. As for democracy and civilization, we can not help them by surrendering to the current fashion of passive defeatism. We *can* help them if we are willing to live, in the midst of uncertainty, with the adventurous confidence of hope.

TECHNOLOGICAL TRENDS AND NATIONAL POLICY[1]

ANTICIPATION of the future is the key to adequate planning for the best use of our national resources. It is, however, more difficult to look forward without the aid of precise instruments than it is to look backward with the aid of memory and records. Though this report attempts to deal with the future, it is fully realized that the future grows out of the past and hence that past trends must be studied to determine future trends.

Planning is usually carried on in relation to a specific task, for a definite time, in a limited territory; but changes coming from without these limits may upset the best-laid programs. Thus the chemical inventions making substitutes of wool and cotton from cellulose, gasoline from coal and rubber from coal and chalk may affect cotton, coal and timber production, and no doubt policies in regard to other natural resources. So closely interrelated is the mechanism of modern civilization that a change occurring in one part, say in industry, will produce an effect in a quite different and unexpected part, as for instance, in the schools or the use of natural resources. Hence we need a view of the general causes, types and trends over a broad front, since any specific program may be affected by forces originating elsewhere.

Invention is a great disturber and it is fair to say that the greatest general cause of change in our modern civilization is invention; although it is recognized that social forces in turn encourage or discourage inventions. Certainly developments in technology cause a vast number of changes in a great variety of fields. A banker once defined invention as that which makes his securities insecure. Hence a study of the trends of inventions furnishes a broad perspective of many great movements of change and basic general information for any planning body, however general or specific their plans may be.

THE NATURE OF THE REPORT

The report presents a survey of most of the great fields of technology and applied science, namely, agriculture, mining, transportation, communication, the construction industries, power production, the metallurgical and chemical industries and the electrical manufactures. Chapters on these subjects comprise part III of the report. The purpose is to cover a wide range; for the specialization so necessary for progress needs to be accompanied by broader vision. It was possible to obtain this wider perspective by dealing only with the more significant inventions. Since inventions were selected for this report on the basis of their social significance, omissions are important as truly as inclusions, especially as the surveys were conducted by competent authorities in the different fields.

It has been thought best to focus on the near future, which is defined as the next 20 years; but any blinders that cut off sharply the present, the more distant future or even the recent past would mean an inadequate investigation, since change is a process.

Most planning is not concerned with invention as such, but with the effects of inventions. These social effects come only after widespread use, which may follow long after the patent has been granted. Thus, telephoning for considerable distances has been possible for some time; but it is only in the future that the volume of long distance telephoning will be sufficiently large to have much effect on the relationship of location of residence to location of business or upon the growth of suburb and village. Some inventions that are already highly developed to-day are reported in the pages that follow, since the influences they precipitate will be occurring in the near future. Still more recent inventions will also have influences in the immediate future. The air-conditioning developments which lower inside temperatures during hot weather may or may not within the next generation affect southern cities and stimulate the growth of factories in warmer regions. Or again, tray agriculture, which produces a high yield per plant when the roots are suspended in a tray of liquid chemicals instead of in the soil, may or may not be used sufficiently to be of much social significance within the reader's lifetime. The particular social influences which the inventions here surveyed may have are indicated in many cases by the authors of the chapters in the third part of the report.

Part I of the report is devoted to the social aspects of technology and its relationship to planning in a series of selected topics of special importance, such as technological change and unemployment or resistances to the adoption of inventions. Throughout the report, then, there will be found discussions of the effects of inventions on society, although the many different effects are difficult to foresee. In the case of the airplane, for example, few persons even at the time of the world war foresaw the present influences of the bomber or international relations. There is as yet no science capable of predicting the social effects of inventions,

[1] Foreword to the report of the Sub-committee on Technology of the Science Committee of the National Resources Committee, consisting of Dr. W. F. Ogburn, *chairman;* Dr. John C. Merriam and Dr. E. C. Elliott. The Science Committee consists of Dr. Frank R. Lillie, Dr. E. B. Wilson and Dr. John C. Merriam, appointed by the National Research Council; Dr. E. C. Elliott, Dr. Charles H. Judd and Dr. W. D. Cocking, appointed by the National Council on Education, and Dr. W. F. Ogburn, Dr. H. A. Millis and Dr. Carter Goodrich, appointed by the Social Science Research Council.

and decades will be required for such a development. Until that time each planning unit of government or industry will try to predict the future by drawing its own conclusions as to possible influences of inventions, known and foreseeable.

FINDINGS

(1) The large number of inventions made every year shows no tendency to diminish. On the contrary, the trend is toward further increases. No cessation of social changes due to invention is to be expected. It is customary to speak of the present age as one of great change, as though it were a turbulent transition period between two plateaus of calm, but such a conclusion is illusory. Though the rate of change may vary in the future there is no evidence whatever of a changeless peace ahead.

(2) Although technological unemployment is one of the most tragic effects of the sudden adoption of many new inventions (which may be likened to an immigration of iron men), inventions create jobs as well as take them away. While some technological changes have resulted in the complete elimination of occupations and even entire industries, the same or other changes have called into being new occupations, services and industries.

(3) No satisfactory measures of the volume of technological unemployment have as yet been developed, but at least part of the price for this constant change in the employment requirements of industry is paid by labor since many of the new machines and techniques result in "occupational obsolescence." The growth and decay of industries and occupations caused by technological progress necessitate continuous and widespread —and not always successful—readjustments and adaptations on the part of workers whose jobs are affected by these changes.

(4) The question whether there will be a large amount of unemployment during the next period of business prosperity rests only in part on the introduction of new inventions and more efficient industrial techniques. The other important elements are changes in the composition of the country's production (such as appreciable changes in the proportion which service activities constitute of the total), the growth of population, changes in the demands for goods and services, shift in markets, migration of industry, hiring age policies of industries and other factors discussed in the body of the report.[2] For instance, even if industrial techniques remained the same, the volume of production would have to be greater in the future than in 1929 in order to absorb the increase in the working population and keep unemployment to the level of that date. If the productivity of 1935 (the latest year for which figures are available) continues the same in 1937, and the composition of the nation's total product remains unchanged, production would have to be increased 20 per cent. over that of 1929 to have as little unemployment as existed then. Failing this there will be more unemployment and if labor efficiency is increased by new inventions or otherwise, then the production of physical goods and services must be more than 120 per cent. of what it was in 1929.

(5) Aside from jobs, subtracted or added, new inventions affect all the great social institutions; family, church, local community, state and industry. The committee finds that in all the fields of technology and applied science which were investigated there are many new inventions that will have important influences upon society and hence upon all planning problems. Particularly impressive were new inventions in agriculture, communication, aviation, metallurgy, chemistry and electrical tools and appliances.

(6) A large and increasing part of industrial development and of the correlated technological advances arises out of science and research. Invention is commonly an intermediate step between science and technological application, but this does not make less important the point that the basic ideas upon which these programs are developed come out of scientific discovery or creative activity.

(7) Advance of many aspects of industry and the correlated technologies is dependent upon scientific research and discovery. This fact is made clear by the increasing importance of research laboratories in the great industries. The research conducted is not only well organized but it is carried forward with the cooperation of investigators having high rank in the field of science. If the contribution of research were to be reduced, the industries would tend to freeze in a particular pattern.

(8) Though the influence of invention may be so great as to be immeasurable, as in the case of gunpowder or the printing press, there is usually opportunity to anticipate its impact upon society *since it never comes instantaneously without signals.* For invention is a process and there are faint beginnings, development, diffusion and social influences, occurring in sequence, all of which require time. From the early origins of an invention to its social effects the time intervals average about 30 years.

(9) While a serious obstacle to considering invention in planning is lack of precise knowledge, this is not irremediable nor the most difficult fact to overcome. Other equally serious obstacles are inertia of peoples, prejudice, lack of unity of purpose and the difficulties of concerted action.

(10) Among the resistances to the adoption of new inventions and hence to the spread of the advantages

[2] See pt. I, sec. 5.

of technological progress there is specially noted those resistances arising in connection with scrapping equipment in order to install the new. Better accounting methods and greater appreciation of the rate of inventional development facilitates the spread of improved capital goods. The rate of capital obsolescence is especially a major problem under monopolistic conditions, which probably favor the adoption of technological improvements less than do conditions of keen competition.

(11) The time lag between the first development and the full use of an invention is often a period of grave social and economic maladjustment, as, for example, the delay in the adoption of workmen's compensation and the institution of "safety first" campaigns after the introduction of rapidly moving steel machines. This lag emphasized the necessity of planning in regard to inventions.

RECOMMENDATIONS

(1) The reports herewith presented reveal the imminence of a few very important inventions that may soon be widely used with resultant social influences of significance. Since these inventions may deeply affect planning it is recommended that a series of studies be undertaken by the planning agencies herein recommended or by existing planning boards, with the aid of such natural and social scientists as may be needed, on the following inventions: the mechanical cotton picker, air conditioning equipment, plastics, the photoelectric cell, artificial cotton and woolen-like fibers made from cellulose, synthetic rubber, prefabricated houses, television, facsimile transmission, the automobile trailer, gasoline produced from coal, steep-flight aircraft planes and tray agriculture.

(2) A special case of the influence of invention is technological unemployment. It is recommended that a joint committee be formed from the Department of Labor, the Department of Commerce, the Department of Agriculture, Bureau of Mines, Interstate Commerce Commission, Social Security Board and the Works Progress Administration with such other cooperation as may be needed, for the purposes of keeping abreast with technological developments and ascertaining and noting the occupations and industries which are likely to be affected by imminent technological changes and the extent to which these inventions are likely to result in unemployment. It is recommended that such information be made available through the appropriate departments to the industry and labor likely to be affected.

(3) In view of the findings regarding the importance of technology and applied science, it is recommended that the Federal government develop appropriate agencies for continuous study of them; and more specifically that there be set up in the respective departments science committees with the definite function of investigating and reporting at regular periods on the progress and trends of science and invention and the possible and economic effects flowing therefrom as they affect the work of the departments and of the agencies to whom they render service. Copies of such reports should be supplied to the National Resources Board and it is recommended that in so far as is feasible they be made available to the various city, county and state planning boards and to the public.

(4) Since the patent laws have considerable influence on the rate of technological progress, it is recommended that the whole system be reviewed by a group of social scientists and economists. This review, unlike others dealing with specific reforms, technical operations, scientific aspects or ethical implications should be concerned with the articulation of the patenting process with the fundamental processes of human progress and the types of economic systems. From such basic relationships the better adaptation of the system to changing conditions can be worked out in the necessary detail.

(5) It is recommended that the Science Committee of the National Resources Committee, with the cooperation of other scientists that may be needed, make an investigation of the adequacy of the reporting of inventions and of discoveries in applied science and advise on the feasibility (*a*) of more balanced coverage, (*b*) of selecting those more socially significant and (*c*) of the assembling of such data in some central location or locations.

(6) The most important general conclusion to be drawn from these studies is the continuing growth of the already high and rapidly developing technology in the social structure of the nation, and hence the hazard of any planning that does not take this fact into consideration. This pervasive interrelationship so clearly manifest throughout the pages of this report points to one great need, namely, a permanent over-all planning board. Such a board is needed to give breadth of consideration to the variety of factors which affect specific plans. This board would take its place in the governmental pattern as coordinator for the many special planning boards, of which there are now 47 state boards, 400 county boards and 1,100 city boards. The Technology Committee, therefore, makes to the National Resources Committee, as a major recommendation of this report, the creation of a National Resources Board, as recommended by the President's Committee on Administrative Management in their report of January 8, 1937.

OBITUARY

HERBERT ELLSWORTH SLAUGHT

IN the death of Herbert Ellsworth Slaught on May 21, 1937, mathematics in America has lost one of its dominant figures. He was not a research scholar, but he wielded a remarkable influence in the organization and development of the leading American societies for the encouragement of mathematical research, and for the cultivation of inspiring associations among those interested in the study and teaching of mathematics.

His early life was difficult. He was born on a farm near Watkins, N. Y., on July 21, 1861. During his high-school and college years in Hamilton, N. Y., he helped to support his family and at the same time earned his way through Colgate Academy and Colgate University, from which he graduated in 1879 and 1883, respectively, both times as valedictorian of his class. He received his M.A. in 1886 and an honorary Sc.D. from Colgate in 1911.

His first teaching position was an instructorship in mathematics at Peddie Institute in Hightstown, N. J., where he effectively demonstrated his abilities as an instructor and an administrator. After his third year there he was made assistant principal in 1886 and principal in 1889. But his real interest was in his mathematics and his teaching, and in 1892 he accepted a fellowship in mathematics at the University of Chicago, which was just then opening its doors. After the expiration of his fellowship term he was successively appointed reader, associate, assistant and instructor at the University of Chicago during the years 1894–97, and he received his Ph.D. degree in the winter quarter of 1898. His thesis, entitled "The Cross-Ratio Group of 120 Quadratic Cremona Transformations of the Plane," appeared in the *American Journal of Mathematics* (Vol. 22, pp. 343–80, 1900). He was made assistant professor in 1900, associate professor in 1908, professor of mathematics in 1913 and professor emeritus in 1931.

In the early years of the University of Chicago Slaught developed a wide acquaintance with teachers of mathematics in the central west as a result of his duties as representative of the university in its relations with affiliated secondary schools. His experience during these years undoubtedly had great influence in his decision, formed after a very conscientious debate with himself, to devote his life to the promotion and improvement of the teaching of mathematics rather than to a research career. He accordingly affiliated himself enthusiastically in 1903 with the newly formed Central Association of Teachers of Mathematics, and in 1907 was made co-editor of the *American Mathematical Monthly*. From that time on much of his energy was devoted to activities associated with the *Monthly*, and to the organization and development of the Mathematical Association of America, devoted to the interests of collegiate mathematics, in contrast to the older American Mathematical Society, whose chief purpose is the promotion of research.

Many scientists have expressed surprise that there should be two distinct national mathematical societies. The older one will celebrate its semi-centennial next year. The younger one was founded in 1916, mainly on the initiative of Professor Slaught, and its phenomenal growth and success has been due largely to his insight, judgment, energy and tenacity. The new association did not arise by secession from the older society. It arose from Slaught's inspiration to grasp the best solution of the problem to finance permanently the *American Mathematical Monthly*, which had become largely his responsibility.

The *Monthly* was founded in 1894 by B. F. Finkel, of Drury College in Springfield, Missouri. In October, 1902, L. E. Dickson became co-editor in charge of articles. From 1905–1908 it was published under the auspices of the University of Chicago. Dickson (who withdrew at the end of 1908) persuaded Finkel to invite Slaught to become an editor in 1907. During 1909–12, the *Monthly* was published with the cooperation of the Universities of Chicago and Illinois. During 1913–15, Slaught secured the cooperation of fourteen leading western universities. But he found that this method of financing the *Monthly* could not be made permanent. Hence he and his associates proposed to the American Mathematical Society that, in addition to its publishing its *Transactions* and *Bulletin*, it should finance and edit the *Monthly*. The latter caters to collegiate mathematics, while the two journals of the society publish only original papers or critical reviews of them. The society decided against the proposal and thus reaffirmed that its sole object is the support of research.

Accordingly the Mathematical Association of America was founded in 1916 under the presidency of E. R. Hedrick, now provost of the University of California at Los Angeles. For twenty years, Slaught has been the leader in the association and was its president in 1919. For thirty years, he was one of the editors of the *Monthly*. He was remarkably effective in these activities. He forecast the future with uncanny foresight, showed remarkable judgment in selecting his associates and secured their full friendly cooperation.

But Slaught's activity did not end with his interest in the association. During the years 1916 to 1922 the association had a committee which, under the leadership of Professor J. W. Young, of Dartmouth College, investigated the teaching of mathematics in secondary schools and formulated for them a standard mathe-

matical curriculum. Its report, prepared with the aid of many groups of teachers in widely scattered communities, is one of the most valuable documents in its field. Slaught believed that the cooperative spirit and the associations stimulated by the work of this committee should be kept alive, and he proposed the organization of an association to be called the National Council of Teachers of Mathematics, whose membership should be drawn from the ranks of those interested in the teaching of mathematics in the secondary schools. The council began its existence in 1920. It now has an official journal called *The Mathematics Teacher,* a series of year-books containing valuable articles on the place of mathematics in modern education, and more than 5,000 members.

Slaught was also one of the first members of the Chicago Section of the American Mathematical Society and a most efficient secretary of the section from 1906 to 1916. He early recognized the value of cooperation between the society and the association, and his effective encouragement of such cooperation has constituted a most important service to mathematics in this country. He was at various times a member of the council of the society, trustee and president and honorary life president of the association, honorary life president of the National Council, and honorary life member of the Central Association. He has thus for many years been influential in the affairs of the most important of the mathematical associations of our country.

Slaught's connections with mathematical societies involved him in many editorial responsibilities. He was for many years managing editor of the *American Mathematical Monthly,* was an editor of the *Mathematics Teacher,* and he was one of the founders of the *Educational Screen,* a periodical devoted to the promotion of visual education. In 1923 he conceived the idea of a series of mathematical books, to be sponsored by the association, which would present in expository form the results of modern research in pure and applied mathematics. Five of the books have already appeared and a sixth is in preparation, under the auspices of a committee of which Slaught was chairman. The books are called "Carus Mathematical Monographs" after the late Mrs. Mary Hegler Carus, of LaSalle, Ill., who generously financed the early volumes.

Slaught was unsurpassed as a teacher of collegiate mathematics. He was on many occasions the ablest representative of our department of mathematics at the University of Chicago in our relations with the university and our students. He was widely known and beloved by our alumni. We have lost an influential colleague whose cheerfully cooperative spirit and whose devotion to his university and to mathematics have been an inspiration to all of us.

L. E. DICKSON
G. A. BLISS

RECENT DEATHS

DR. PERCY EDGAR BROWN, head of the department of agronomy of the Iowa State College, died on July 8 at the age of fifty-one years. Dr. Brown had been secretary and this year became chairman of the Section on Agriculture of the American Association for the Advancement of Science. He was also editor-in-chief of the Iowa State College *Journal of Science.*

PROFESSOR ARTHUR E. SEAMAN, of the Michigan College of Mining and Technology, Houghton, died on July 9 at the age of seventy-nine years. He had been connected with the college department of geology since 1891, and retired in 1928 with the title of professor emeritus and curator of the college museum which bears his name.

DR. JOHN W. CHURCHMAN, professor of therapeutics at Cornell University Medical College, died on July 13 at the age of sixty years.

WINTER LINCOLN WILSON, formerly professor of railway engineering at Lehigh University, died on July 15 at the age of seventy years.

DR. HENRY EDWARD ARMSTRONG, emeritus professor of chemistry at the City and Guilds College at South Kensington, the oldest fellow of the Royal Society, died on July 13. He celebrated his eighty-ninth birthday on May 6.

DR. HENRY HOMAN JEFFCOTT, secretary of the British Institution of Civil Engineers for fifteen years, previously professor of engineering in the Royal College of Science, Dublin, died on June 29.

DR. F. H. HESSELINK VAN SUCHTELEN, who had published research in soil chemistry, died as a result of an accident at Apeldoorn, Holland, on June 23 at the age of fifty-three years. Dr. van Suchtelen was for some years connected with the New Jersey Agricultural Experiment Station, the Michigan State College and the Massachusetts Agricultural College.

SCIENTIFIC EVENTS

THE BRITISH TRUST FOR ORNITHOLOGY

THE British Trust for Ornithology, according to the London *Times,* has accepted responsibility for the future conduct of the principal scheme in Great Britain for the study of migration and other aspects of bird life by the ringing method. This scheme was instituted in 1909 by H. F. Witherby, editor of *British Birds,* and has been maintained with the cooperation of

readers of that journal. Over 500,000 birds have been marked to date.

The trustees of the British Museum (Natural History) are providing headquarters in the Bird Room at South Kensington and permit the address of the museum to be used. Rings will in future be inscribed "British Museum (Natural History), London," instead of "Witherby High Holborn London," with an identification number as before.

The plan will be directed by a committee as follows: Dr. A. Landsborough Thomson (chairman), A. W. Boyd, A. B. Duncan, P. A. D. Hollom, Lord Ilchester, Lord Mansfield, H. F. Witherby and Miss E. P. Leach (hon. secretary). *British Birds* will continue to publish the results.

The ringing of wild birds has shown exactly where some of our summer visitors go in winter. More than a dozen swallows ringed in Great Britain as nestlings have been reported from South Africa; conversely starlings have been ringed in Great Britain in winter and recovered in Norway in summer above the Arctic Circle; others have been shown to come from Northern Germany and the Baltic States; but native British starlings are non-migratory. Unexpected movements have come to light. Several kittiwake gulls ringed on the Farne Islands have now been recovered in Newfoundland and Labrador; the species is also native on that side of the Atlantic. The swallow, again, is shown to return to the place of birth or previous breeding; birds ringed as adults often return to the same house or barn, and birds ringed when young return commonly to the same district.

Differences in behavior between individuals of a species have been noted; of lapwings hatched in Scotland or the north of England, some remain there throughout the winter, some cross to Ireland and some travel to Portugal. Light has also been thrown on longevity and on constancy to mates. The aluminium rings are no inconvenience to the birds and the ringing is entrusted only to competent collaborators.

THE ATOMIC-PHYSICS OBSERVATORY OF THE CARNEGIE INSTITUTION OF WASHINGTON

A MAJOR event last year in physical science was the direct observation and measurement by investigators in the Carnegie Institution's Department of Terrestrial Magnetism at Washington of the basic forces which bind together the primary building blocks of matter—protons and neutrons—to form the nuclei of all atoms heavier than hydrogen. The principal experiments were those made on the elastic "scattering" of high-speed protons through various angles after collisions with stationary protons. A proton-beam from the million-volt equipment was passed through hydrogen gas. The angular scattering to be expected because of the like positive charges on two protons was known and was approximately confirmed at 600,000 volts. At 900,000 volts a markedly different and increased scattering was found, demonstrating that a large "new" force (superposed on the familiar electrical repulsion) was being encountered abruptly at these correspondingly closer distances of approach. The experiments were made in Washington by Drs. M. A. Tuve, L. R. Hafstad and N. P. Heydenburg, of the staff of the Department of Terrestrial Magnetism. The most significant results of the experiments were brought out by their colleague, Professor G. Breit, of the University of Wisconsin, a research associate of the institution. A detailed theoretical analysis by Dr. Breit and his associates, Professor E. U. Condon, of Princeton, and Dr. R. D. Present, of Purdue, showed that the "new" force exhibited in these experiments was an attraction and not an additional repulsion (as for elastic spheres); also that the proton-proton, proton-neutron and neutron-neutron interactions—the three forces which underlie the structure of all atomic nuclei—are all attractive and of nearly identical magnitude.

Dr. J. A. Fleming, director of the Department of Terrestrial Magnetism, states that the institution has made provision that the department's investigators will shortly be equipped to carry these studies to still closer "distances of approach" between particles, and subject these universally important forces to a still more detailed examination. This will be done through the use of the exceedingly high voltages—above 5,000,000 volts—which will be available under precision control with a new super-voltage equipment, construction on which was begun on May 20, at the department's laboratory in Washington.

This installation, planned in detail several years ago as an embodiment of many years of experience by this pioneer high-voltage laboratory for nuclear physics, has been given the designation "Atomic-Physics Observatory." It comprises an electrostatic generator of large size and associated high-voltage vacuum-tube, mounted inside an egg-shaped pressure-vessel of steel 55 feet high which will contain dry air compressed to 50 pounds per square inch. Beneath this vessel is a subterranean observing-room and separate control-room joined by a tunnel-maze. Earth is thus utilized for shielding against the dangerously intense gamma rays and neutrons which will be produced. The above-ground steel pressure-vessel with its dome 37½ feet in diameter reduces at the bottom to a segment of a sphere 15½ feet in diameter in an overall height of 55 feet. A circular brick curtain-wall 35½ feet in diameter will be added after completion of the pressure-vessel and thus the completed structure will resemble an astronomical observatory.

Since the regions of space to the study of which this large equipment is dedicated are approximately as remote from our world of ordinary dimensions in the direction of minuteness as are the farthest spiral nebulae in the direction of greatness, and since these small regions to a large extent are equally inaccessible as regards individual selection or detailed examination, the novel use of the word "observatory" may be more appropriate than perhaps appears at first sight.

A similar equipment is also under construction at the Westinghouse Research Laboratories in Pittsburgh under the supervision of Dr. William H. Wells, formerly (1933–1934) associated with the staff of the Carnegie Laboratory.—*Correspondent.*

THE SCIENTIFIC EXHIBIT OF THE AMERICAN MEDICAL ASSOCIATION

THE Scientific Exhibit at the Atlantic City session of the American Medical Association, according to the *Journal* of the association, was characterized by the high character of exhibits presented. There were 254 exhibits in all, of which 219 were presented by individual exhibitors; twenty-five by government and national organizations; five by councils and bureaus from the American Medical Association headquarters, and two special exhibits subsidized by the Board of Trustees.

The special exhibit on anesthesia was presented under the auspices of a committee composed of D. Chester Brown, chairman, Danbury, Conn.; Frank H. Lahey, Boston, and Paul Nicholas Leech, Chicago, assisted by members of the Associated Anesthetists of the United States and Canada, the American Society of Anesthetists and the American Society of Regional Anesthesia. In addition to continuous demonstrations by a competent corps of demonstrators, there were talks and motion pictures throughout the week in an area adjoining the exhibits. A pamphlet describing the exhibit was distributed.

The special exhibit on fractures was presented under the auspices of a committee composed of Kellogg Speed, chairman, Chicago; Frank D. Dickson, Kansas City, Mo., and Walter Estell Lee, Philadelphia, assisted by an advisory committee composed of Isidore Cohn, New Orleans; H. Earle Conwell, Birmingham, Ala.; Frederic J. Cotton, Boston; Richard B. Dillehunt, Portland, Ore.; Eldridge L. Eliason, Philadelphia; Leo Eloesser, San Francisco; George W. Hawley, Bridgeport, Conn.; Melvin S. Henderson, Rochester, Minn.; James M. Hitzrot, New York; William L. Keller, Washington, D. C.; Roy D. McClure, Detroit; Frank R. Ober, Boston; Dallas B. Phemister, Chicago, and J. Spencer Speed, Memphis, Tenn. More than fifty physicians from various parts of the country assisted with the demonstrations. Acknowledgment is made to the Surgeon General of the United States Army, Major A. S. Dabney, Major W. W. McCaw, soldiers from the Walter Reed Hospital, Dr. James H. Mason, III, of Atlantic City, and Mrs. Mildred Jones and Miss Flora Keats, nurses from the Atlantic City Hospital, for the very efficient service which they rendered in connection with the fracture exhibit. Appreciation is also expressed to the management of the Atlantic City Hospital for its cooperation.

Other features of the Atlantic City session included a symposium on pneumonia by the Section on the Practice of Medicine, a symposium on heart disease composed of twenty-five exhibits presented in cooperation with the American Heart Association, and motion picture programs by the Section on Obstetrics, Gynecology and Abdominal Surgery, by the Section on Ophthalmology and by the Section on Orthopedic Surgery, shown in spaces adjoining the exhibits of those sections.

An endeavor was made to correlate the exhibits with papers read before the various sections of the Scientific Assembly, with the result that fifty papers were accompanied by material in the Scientific Exhibit.

THE NATIONAL CONFERENCE ON WEIGHTS AND MEASURES

Two hundred and thirty-one members and guests attended the twenty-seventh National Conference on Weights and Measures which was held in Washington from June 1 to 4. According to the account of the meeting given in the *Technical Bulletin* of the National Bureau of Standards, delegates from thirty-one states and the District of Columbia were present as well as representatives of manufacturers of weighing and measuring appliances and others interested in weights and measures.

The sessions were opened with an address by Dr. Lyman J. Briggs, president of the conference, who presented a proposal for legislation to fix the standards of weights and measures of the United States. The Secretary of Commerce, the Honorable Daniel C. Roper, also addressed the conference on June 3, his subject being "Sustaining Standards through Cooperation." In all thirteen papers were presented and discussed, while many other subjects not specifically listed on the program received attention at the general session on the morning of June 2.

Perhaps the most important actions taken were the endorsement of the proposed bill to fix the standards of weight and measure for the United States, the endorsement of a bill to standardize the sizes of cans for food products and the amendment of certain codes of specifications and tolerances for commercial weighing and measuring apparatus, particularly the tolerances for vehicle scales.

An exhibition of recent developments in weighing and measuring apparatus was arranged in connection

with the meetings, and the bureau was able to demonstrate the use of its new vehicular scale-testing unit by a complete test of a 40,000-pound motor-truck scale at the United States Naval Academy, in Annapolis. Buses were provided to carry the members to and from the academy. A tour of the bureau's laboratories was also arranged, featuring particularly the work of the Weights and Measures Division.

At the last session, on June 4, the following officers were elected for the ensuing year: *President,* Dr. Lyman J. Briggs, director, National Bureau of Standards; *Vice-presidents,* W. S. Bussey, of Texas; C. J. P. Cullen, of Pennsylvania; J. J. Levitt, of Illinois, and R. E. Meek, of Indiana; *Secretary,* F. S. Holbrook, National Bureau of Standards; *Treasurer,* Geo. F. Austin, Jr., of Detroit, Mich.

WOODS HOLE CONFERENCE ON THE PROBLEM OF AGING

THE main function of the Union of American Biological Societies is the promotion of *Biological Abstracts.* The union is interested, however, in any activity which will tend to focus otherwise divergent biological specialties on a specific problem of fundamental importance. The problem of aging belongs in this category. Its investigation is timely; because, with improved living conditions and advances in the medical sciences, people on the average live longer, so that the services of proportionally more elderly individuals are available. Over the same period unemployment has increased, which results in a tendency to enforced earlier retirement or failure to employ men and women past maturity to give place to younger groups. Two factors therefore operate in the same direction to accentuate the social problem of the place of the aged as useful members of the community. Though they may not be 100 per cent. effective, the 80 or 50 per cent. or whatever it may be should not be entirely lost. The kind of service to be performed must also be considered. Aging is at the present time our greatest and most neglected human problem. Scientific data on its biological and medical aspects are urgently needed. Consequently, the union sponsored a conference on the problem viewed from these angles held at the Cape Codder Hotel, Woods Hole, Mass., on June 25 and 26. The Divisions of Medical Sciences, Biology and Agriculture and Anthropology and Psychology of the National Research Council cooperated. The expense of the conference was defrayed by a grant from the Josiah Macy, Jr., Foundation. Those attending the conference were: A. J. Carlson, Alfred E. Cohn, E. V. Cowdry, William Crocker, Louis I. Dublin, E. T. Engle, Lawrence K. Frank, Jonas S. Friedenwald, Alfred Friedlander, W. S. Hunter, H. S. Jennings, E. B. Krumbhaar, C. M. McCay, Wm. deB. MacNider, E. D. Merrill, Walter R. Miles, Jean Oliver, F. Fremont-Smith, T. Wingate Todd and Clark Wissler. They include representatives of the union, the council, the foundation, contributors to a book on aging being prepared by the foundation and other interested persons.

E. V. COWDRY

SCIENTIFIC NOTES AND NEWS

DR. MARSTON T. BOGERT, professor of organic chemistry at Columbia University, has been elected an honorary fellow of the Royal Society of Edinburgh. Other fellows elected included: Professor C. U. Ariëns Kappers, professor of comparative neurology in the University of Amsterdam and director of the Central Institute of Brain Research, and Professor Max Planck, emeritus professor of theoretical physics and director of the Institute for Theoretical Physics in the University of Berlin.

AT the commencement exercises of the University of Michigan, the degree of doctor of engineering was conferred on Dean R. L. Sackett, of the School of Engineering of the Pennsylvania State College, who resigned at the close of the college year and was made dean emeritus. The degree was also conferred on Professor Henry E. Riggs, honorary chairman of the department of civil engineering of the University of Michigan.

AT the recent centennial celebration of Mount Holyoke College, the degree of doctor of science was conferred on Dr. Margaret Tyler, associate clinical professor at the Yale Medical School; on Dr. Anna Pell Wheeler, chairman of the department of mathematics of Bryn Mawr College, and on Dr. Margaret C. Ferguson, research professor of botany at Wellesley College.

AT the fourth centenary celebration of the University of Lausanne, the degree of doctor of medicine (*in absentia*) was conferred on Sir Frederick Gowland Hopkins, Sir William Dunn professor of biochemistry at the University of Cambridge, and the degree of doctor of pharmacy was conferred on Dr. G. Barger, professor of chemistry in relation to medicine at the University of Edinburgh.

The British Medical Journal reports that at the celebration of the hundredth anniversary of the founding of the University of Athens, honorary doctorates were conferred on: Sir Charles Sherrington, Oxford; Professors O. Naegeli, Zurich; von Koranyi, Budapest; L. Aschoff, Freiburg; Augustus Bier, Berlin; R. Krehl, Heidelberg; Hymans van den Bergh, Utrecht; and J. Wagner von Jauregg, Vienna.

THE University of St. Andrews on July 5 conferred the doctorate of laws on Dr. G. F. Stout, emeritus professor of logic and metaphysics, and on Dr. W. T. Calman, president of the Linnean Society, lately keeper of the department of zoology in the British Museum.

SIR HARRY LINDSAY, director of the British Imperial Institute, has accepted nomination as president of the Association of Special Libraries and Information Bureaux for the year 1937–38. The association will hold its fourteenth annual conference at Gonville and Caius College, Cambridge, during the week-end beginning on September 24.

THE William H. McFadden Medal of the American Foundrymen's Association has been awarded to Charles Willers Briggs, of the United States Naval Research Laboratory at Anacostia, D. C.

THE council of the Royal Society of Arts has awarded the Albert Medal for 1937 to Lord Nuffield, who recently gave a large sum to the University of Oxford for the endowment of medical research, "for services to industry, transport and medical science." The medal was instituted in 1862 as a memorial to the Prince Consort, for eighteen years president of the society, and is awarded annually for "distinguished merit in promoting arts, manufactures or commerce."

DR. CARL C. MONRAD, of the Standard Oil Company of Indiana, for the past seven years a chemical engineer in the research department at Whiting, has been appointed associate professor of chemical engineering at the Carnegie Institute of Technology.

DR. CHARLES S. MCCLESKEY, formerly assistant professor in the department of bacteriology of the Iowa State College, has been appointed associate professor of bacteriology at the Louisiana State University. Dr. McCleskey is visiting professor at the university this summer and will take up his work as a regular member of the faculty next term.

AT the Long Island College of Medicine, Brooklyn, N. Y., Dr. Jean A. Curran has been appointed dean, and Dr. Tasker Howard, professor of clinical medicine, has been appointed professor of medicine and physician-in-chief to the Long Island College Hospital, to succeed the late Dr. Luther F. Warren. A separate department of preventive medicine and community health has been established under the direction of Dr. Alfred E. Shipley. Dr. Robert L. Moorhead has been appointed professor of clinical otolaryngology, and Dr. Fedor L. Senger, formerly assistant clinical professor in the department of urology, has been promoted to the professorship of clinical urology. They succeed, respectively, Dr. C. W. Stickle and Dr. J. S. Read, who have retired with the title emeritus.

PROFESSOR JACQUES PARISOT, head of the department of hygiene and preventive medicine at the University of Nancy, has been elected chairman of the committee of hygiene of the League of Nations to succeed Dr. Thorvald Madsen, director of the Royal Serologic Institute of Copenhagen.

DR. DANIEL BUCHANAN, dean of the faculty of arts and sciences at the University of British Columbia, is conducting two courses in astronomy during the summer session of the University of California at Los Angeles.

DR. MONROE DAVIS EATON, last year associate professor of bacteriology and immunology at Washington University School of Medicine, St. Louis, has resigned to become associated with the International Health Board of the Rockefeller Foundation of New York.

DR. GLENN FRANK, for twelve years president of the University of Wisconsin, has become president of Rural Progress, Inc., and editor of the magazine, a monthly agricultural publication.

MEMBERS of the Canadian National Research Council elected for three-year terms are Sir Frederick Banting, head of the Banting Institute of the University of Toronto, and Professor E. F. Burton, head of the department of physics; W. R. Campbell, Windsor, general manager of the Ford Motor Company of Canada; Professor R. H. Clark, head of the department of chemistry, University of British Columbia, and Professor E. P. Fetherstonhaugh, dean of the faculty of engineering and architecture, University of Manitoba.

THE London *Times* states that the Secretary of State for Scotland and the Minister of Agriculture and Fisheries have appointed Dr. W. L. Burgess, Dr. W. R. Wooldridge, Sir Louis J. Kershaw and Professor Sir Joseph Barcroft to be members of the committee set up in November, 1936, to review the facilities available for veterinary education in Great Britain. Mr. Thomas Loveday, vice-chancellor of the University of Bristol, has been appointed chairman.

DR. GRANT FLEMING, professor of public health and preventive medicine and dean of the faculty of medicine at McGill University, is making a critical study of the administration of seven county units of the Michigan community health program sponsored by the W. K. Kellogg Foundation, at Battle Creek, Mich.

DR. CHARLES N. FREY, director of the Fleischmann Laboratories, New York City, was a delegate from the United States to the Technical and Chemical Congress of Agricultural Industries held at Scheveningen, Holland, from July 12 to 19.

DR. VICTOR G. HEISER has returned to the United States after an absence of six months during which he

made a study of leprosy in southern Africa. He plans to raise a fund of two million dollars for a study of the disease, its prevention and cure. Great Britain has volunteered $100,000 annually toward the leper general fund.

DR. AUSTIN W. CHEEVER has left for the Cherokee Indian Reservation in North Carolina, where he will carry on research on the skin diseases of the American Indians in connection with the Harvard School of Tropical Medicine.

PHILIP S. SMITH, chief Alaskan geologist of the U. S. Geological Survey, left Washington on June 11 to attend the International Geological Congress at Leningrad and Moscow. He will participate in pre-congress and post-congress geological excursions to the Caucasus and Armenia, and will return by way of Siberia and the Pacific route.

J. C. REED, of the U. S. Geological Survey, spent the last two weeks in June in Idaho, where he continued his work on the placer deposits of central Idaho in the vicinity of Grangeville. He reviewed the situation with S. R. Capps, formerly of the Alaskan Branch, who is conducting placer studies in that region. Mr. Reed will be engaged for the remainder of the summer in field work on placers of southeastern Alaska, for the Alaskan Branch.

AN expedition led by Dr. George W. Crile, emeritus professor of clinical surgery at Western Reserve University and director of the research laboratories of the Cleveland Clinic Foundation, will leave about August 1 for a six-week trip into the Canadian Arctic for research on the energy-releasing mechanism of Arctic animals.

DURING the spring semester at Bard College, Annandale-on-Hudson, N. Y., evening lectures were given before the Science Colloquium by Professor Selig Hecht, of Columbia University, on various phases of the photochemistry of vision, and by Professor Robley D. Evans, of the Massachusetts Institute of Technology, on the distribution of radioactive elements, radium poisoning and the biological effects of slow electrons.

BY invitation of the Conference on Canadian-American Affairs, held at Queens University during the week of June 14, Dr. Derwent Whittlesey, associate professor of geography at Harvard University, led a discussion of papers on Canadian-American geography. As part of the program of the annual Harris Institute on International Relations at the University of Chicago, held from June 21 to 28, he conducted a round table, preceded by a lecture on "Reshaping the Map of West Africa."

THE corporation of the Marine Biological Laboratory, at Woods Hole, will hold its annual meeting on August 11.

THE American Ethnological Society announces the establishment of a new series, "Monographs of the American Ethnological Society," to be issued annually, beginning in 1938. The object of the society in establishing this series is to furnish a new medium for the publication of longer studies. The board of editors, consisting of Dr. Clark Wissler, *chairman;* Dr. A. I. Hallowell and Dr. Alexander Lesser, will select the study to be published in 1938 from manuscripts submitted on or before February 1, 1938. Manuscripts should not exceed 75,000 words (about 175–200 pages of print); must be in the field of ethnology and should be in condition for printing. They should be addressed to the secretary of the American Ethnological Society, Department of Anthropology, Columbia University, New York City.

THE European Sections of the International Committee for Bird Preservation met in Vienna on June 30 and the three following days. Among the subjects discussed were the proposals for a new convention for the preservation of the birds of Europe; the protection of the quail, and the appointment of an international sub-committee to investigate the conditions under which birds are transported by sea and the means of improving them.

SENATOR WALTER F. GEORGE, of Georgia, introduced on June 14 a bill for the national incorporation of the American Chemical Society, now incorporated under the laws of New York.

AT the last meeting of the academic year of the Board of Trustees of Cornell University, it was ruled that no more students would be admitted to study medicine at Ithaca after June 30, 1938. Students in the Cornell Medical College have had the option of taking their first year at Ithaca and the remainder of their course at the Cornell University Medical Center in New York City. The division of medicine at Ithaca will be continued as a center of research and of service to the colleges of the university.

THE Supreme Court of the State of Illinois has refused to review the decision of the Appellate Court, which decision declared that the City of Chicago has the right to furnish dogs to the institutions which qualified under the terms of an ordinance passed December 1, 1931, and that the ordinance is legal. The ordinance is as follows: "Whenever any reputable institution of learning, hospitals, or their allied institutes in the City of Chicago shall make application to the Commissioner of Health for permission to use humanely unclaimed impounded animals for the good of mankind and the increase of knowledge relating to the cause, prevention,

control and care of disease, the Commissioner of Health, on being satisfied that the said animals are to be so used, shall request the Commissioner of Police to surrender said animals as applied for by the said institutions of learning, hospitals or their allied institutes, and thereupon it shall be the duty of the Commissioner of Police to cause said animals to be surrendered by the Poundmaster to said institutes of learning, hospitals or their allied institutes for said uses."

AN affiliation has been established between the New York City Department of Hospitals and the medical departments of Columbia University, Cornell University and New York University, respectively, for the organization of Welfare Hospital as a teaching and research center. The medical staff of Welfare Hospital will comprise three college divisions: First Division, affiliated with Columbia University, College of Physicians and Surgeons; Second Division, affiliated with Cornell University Medical College; Third Division, affiliated with New York University College of Medicine. The three divisions are of equal rank. The following nominations for the medical board and staff of the hospital have been received from the affiliated medical colleges and have been approved: *Columbia University College of Physicians and Surgeons:* Dr. Randolph West, director of medicine; Dr. William Barclay Parsons, director of surgery; *Cornell University Medical College:* Dr. Irving Sherwood Wright, director of medicine; Dr. Ralph Firestone Bowers, director of surgery; *New York University College of Medicine:* Dr. Norman Jolliffe, director of medicine; Dr. William Howard Barber, director of surgery.

GROUND was broken on June 8 for the new twelve-story building of the Memorial Hospital for the Treatment of Cancer and Allied Diseases in New York City. The new hospital adjoins the Rockefeller Institute for Medical Research and the New York Hospital and Cornell University Medical College, with which Memorial Hospital is affiliated. The site was given by John D. Rockefeller, Jr. A year ago the General Education Board made a grant of $3,000,000 toward the erection and equipment of the institution. It is expected that the building will be completed within two years. Plans for the new hospital were drawn by James Gamble Rogers and Henry C. Pelton. The building contract has been awarded to Marc Eidlitz and Son, Inc. The building will front on Sixty-eighth Street. It will provide at the outset 168 beds, and will also have facilities for diagnostic and treatment clinics, surgery, research laboratories, out-patient service, x-ray and radium treatment.

CONSTRUCTION work on the extension of the University Hospital of the School of Tropical Medicine at San Juan, Puerto Rico, was begun on May 1. The plans which have been accepted call for an expenditure of $240,000 and will provide for extra research facilities in clinical and surgical tropical medicine. On May 27, three acres of the land east of the present research laboratories of the institution were transferred to the school for future building purposes. This land was formerly in the possession of the U. S. Army and has an approximate evaluation of $378,000. Plans have been practically completed for the new animal and primate house which is to be built on a part of this site. The school has also acquired the Island of Santiago, off the east coast of Puerto Rico, composed of thirty-four acres of wooded land, for a free ranging colony of primates. These animals are to be used in connection with the experimental work of the institution and for special studies in psychobiology under the direction of Dr. C. R. Carpenter, of Columbia University. Dr. Carpenter is now in Siam collecting primates, primarily the gibbon (Hylobates).

THROUGH the generosity of John B. Laing, of Lewisburg, West Virginia, president of the Little Stony Game and Fish Preserve, the Virginia Polytechnic Institute has recently acquired for the use of its biology department a tract of 2,500 acres of land in Giles County, Virginia. This tract lies adjacent to and between the Jefferson National Forest and lands aggregating 11,000 acres which the University of Virginia Biological Station and the Little Stony Game and Fish Preserve own. The 2,500 acre tract which will be conducted by the Virginia Polytechnic Institute has an elevation varying between 2,000 and 4,000 feet above sea level and is covered extensively with second growth hardwoods. Numerous springs, small streams and several bogs on the area provide a variety of flora and fauna which includes most species found from Virginia to Canada. It is planned to manage the area so that primitive conditions will be restored generally, although some demonstration wildlife and forestry management will be undertaken. Only eighteen miles from the college and near a good road, the tract will be of value for advanced students in wildlife conservation, forestry, botany, zoology, plant pathology and entomology.

DISCUSSION

AN OLD ANSWER TO A PRESENT-DAY PROBLEM

THE letters of Hess, MacClintock and Shepard published in SCIENCE for April 3, 1936, June 26, 1936, and June 18, 1937, deal with the hypothesis of a change in the earth's rate of rotation, proposed in order to produce a change in oceanic depths and thus to account

for the now submerged canyons along the continental coasts.

Professor Shepard makes the point that the parallel of 35° is a nodal line, at which there would be no change of sea level but about which sea level would oscillate, rising (for increased velocity of rotation) below 35° and falling for higher latitudes. Therefore, says Professor Shepard, the hypothesis is inadequate to explain submerged valleys north of 35°. Professor Hess in SCIENCE for June 18 replies in effect that the distribution of land and water is such that the nodal parallel of latitude might be 55° or 60°.

The problem of change of level due to changing ellipticity of the earth and ultimately to a change in its rate of rotation has a strong analogy to the problem of the tides. The deformation of the level surfaces is of the same type and a change in sea level due to a change of ellipticity is essentially a change of level due to a quasi-permanent long-period tide.

The problem of the effect of the distribution of land and water on the tide, in so far as the level surfaces of the water coincide with the level surfaces of the field of force, was treated in Kelvin and Tait's "Treatise on Natural Philosophy" but is set forth more clearly and at greater length in an article by G. H. Darwin and H. H. Turner in the *Proceedings of the Royal Society* of London (Vol. 40, pp. 303–315, 1886). This article is reproduced in Darwin's "Scientific Papers," Vol. I (Cambridge, England, 1907) pp. 328–339.

The nodal line for long-period tides is in latitude 35° 16′ for an earth completely covered with water. The correction for the presence of land changes this figure very little. Darwin and Turner, in evaluating it, schematize the actual coast line a little and thus obtain figures varying between 33° 29′ and 35° 04′. Professor Shepard's point seems therefore well taken; the nodal line remains near 35° north or south latitude.

This calculation ignores the self-attraction of the water. This may readily be allowed for in the case of an earth covered with water; it increases the tidal or rotational effects about 12 per cent. In the case of the actual earth theoretical solutions have been sketched, but no one has undertaken the enormous labor of a numerical evaluation. Presumably it affects the essential result but slightly.

These calculations assume steep walls at the coast line, with no laying bare of shoals or flooding of lowlands. It is to be presumed that effects of this sort have little effect on the final conclusion, especially in view of the fact that it is difficult to accept a change in the earth's rotation sufficient to cause any great change in the depth of the ocean within Recent, Pleistocene or even remoter time, a change sufficient to account for known submarine canyons.

The change in the difference between equatorial and polar radii due to a change of 1 per cent. in the rate of rotation is

$$\frac{1}{100} \times \frac{1}{289} \times 6370 = 0.22 \text{ kilometers}$$

The factor $\frac{1}{100}$ is the assumed 1 per cent. and may be replaced at pleasure by $\frac{2}{100}$ or by any other small fraction. The factor $\frac{1}{289}$ depends on the rate of rotation, the acceleration of gravity and the size of the earth, which latter appears again as 6,370 km, the mean radius.

This simple calculation assumes a rigid earth covered by water. The change in the difference between equatorial and polar radii then means difference in the depth of the ocean. It allows only for the direct effect of rotation and neglects the yielding of the earth and the self-attraction of matter. There is no absolutely unyielding substance, and matter is self-attracting. The proper factor to allow for these in the case of elastic yielding is imperfectly known, but, from observations of earth tides, appears to be between 0.70 and 0.85. The result of applying this factor is the relative observable change in level between land and water.

If the yielding were plastic instead of elastic, the factor would be about 2 for the ellipticity. But if we consider plastic yielding, we must remember that what we observe is, not the ellipticity, but the displacement of the solid, though plastic, earth relative to the sea and that this is a small second-order effect depending on the depth of the ocean. This means that the computed 0.22 km must be multiplied by a factor between 0.85 and almost zero. A change even of 1 per cent. in the rate of rotation since Pleistocene time seems improbable and an even greater change would not help much in accounting for known submerged canyons.

WALTER D. LAMBERT
U. S. COAST AND GEODETIC SURVEY

THE ANTISCORBUTIC PROPERTIES OF A SALT OF IRON AND ASCORBIC ACID

THE successful use of ferrous-ascorbic acid compounds[1,2,3] in the treatment of secondary anemias has already been recognized to some extent. This present communication concerns itself with an investigation of a salt of reduced iron and the levo-rotatory form of

[1] A. Szent-Györgyi, *Hoppe-Seyler's Zeit. f. Physiol. Chemie*, 225: 168, 1934.
[2] K. Maurer and B. Schiedt, *Biochem. Zeit.*, 285: 6[illegible] 1936.
[3] D. G. Friend, *Jour. Am. Med. Asn.* (in press), 1937.

ascorbic acid which has proved itself non-toxic when administered intravenously to either experimental or human subjects and has been used in this clinic for the treatment of secondary anemias.[3] This salt was found by us to have a highly antiscorbutic property when given intravenously, daily, over a period of six days to a patient with severe scurvy. A daily dose of 250 mgm was sufficient to bring the plasma ascorbic acid level from .02 mgm per cent. to 1.2 mgm per cent. and the withdrawal of marked scorbutic symptoms.

With the cooperation of Dr. Alexander and Dr. Townsend, these findings were confirmed in scorbutic guinea pigs and in normal subjects. An interesting feature in the use of the salt, as is especially demonstrated in normal subjects, is the slow rise in the plasma ascorbic acid content as determined by the method of Pijoan and Klemperer,[4] following its intravenous injection as contrasted to the slope of the values obtained after the injection of ascorbic acid. It would appear from these biological tests that the compound of iron ascorbate breaks down slowly. Chemically, after precipitating the ferrous iron by H_2S as ferrous sulfide and the reduction of the ascorbic acid by H_2S, we were able by the method of Emmerie[5] to recover 97 per cent. of the ascorbic acid. This would indicate that in the salt the double bond of the ascorbic acid molecule is still present, which alone would allow for further reduction to ascorbic and titration with 2.6 dichlorophenol indophenol. The salt as synthesized by us and by Messrs. Hoffman-LaRoche contains 20 per cent. iron and in a 1 M. solution is of pH 6.9. At this pH only one of the hydrogens at the double bond could be replaced by iron. In conclusion, this salt is not only successful in bringing ferrous iron into the treatment of secondary anemias but has valuable antiscorbutic properties in which single daily doses produce prolonged and increased plasma ascorbic acid values.

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THE SURGICAL CLINIC OF THE
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THE MAYNARD PLUM—A CARRIER OF THE PEACH MOSAIC VIRUS

SINCE 1935 plum trees have been suspected of being carriers of the peach mosaic disease in the Palisade district, Colorado, though they show no apparent symptoms of the disease. To investigate this possibility, fresh roots and twigs were taken from six Maynard plum trees growing in an area where heavy losses had been incurred from peach mosaic.

On September 4, 1936, buds from each of these plums were grafted into five one-year-old peach seedling trees, making a total of 30 budded seedling trees. With the beginning of growth in the early spring of 1937, 15 seedling peach trees grafted with buds from parent plum trees Nos. 1, 5 and 6 showed typical symptoms of peach mosaic. The remaining 15 trees grafted with plum buds from parent plum trees Nos. 2, 3 and 4 remained healthy. All buds made growth unions. Twenty-eight seedling peach trees used as control remained healthy. The experiment was conducted in an isolated planting in a remote valley many miles from the mosaic-infected region.

On March 23, 1937, roots collected from the six Maynard plum trees were grafted on roots of 34 two-year-old peach seedling trees. Peach mosaic symptoms were observed on May 15 of the same year on 15 of the 17 peach seedling trees, which were root grafted, using plum trees Nos. 1, 5 and 6 as stock. Two root grafts failed to make growth unions and the peach trees remained normal. Seventeen peach seedling trees root grafted with roots from plum trees Nos. 2, 3 and 4 remained normal also. Thirty-three peach seedling trees used as controls remained free of infection.

From these experiments it appears that plums may be carriers of the peach mosaic virus, though the trees do not show the symptoms evident in the peach.

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A COMPANION WORD FOR PLANKTON

IN SCIENCE for September 25, 1936, I asked for a new word to rank with plankton, but indicating food that is found in the top layer of mud, feeding perhaps as many forms of life as the ones depending upon plankton.

The numerous answers made too extensive text for publication as a group in the limited space that could be devoted to them, but I have selected the gist of the material for brief presentation. Incidentally, in my original letter I should perhaps have added *Accipenser* and larval *Petromyzon* to the group using this food.

Dr. Wm. Rienhoff, Sr., of Baltimore, Md., suggested either Iloen or Ascion, expressing in slime-imbedded organic particles serving as animal foodstuffs in contrast to plankton, expressing free floating material.

Dr. W. A. Dayton, of the U. S. Forest Service, suggested "ilyophagous organisms." He said the Greeks had a word for mud feeder, "borborophagous."

Dr. Carl L. Hubbs, curator of fishes, University of Michigan, suggests "hyperbius."

Dr. Dorothy Cobb Adams, of the Johns Hopkins Hospital, suggested "limous plankton" from *limus*—mud or slime.

[4] M. Pijoan and F. Klemperer, *Jour. Clin. Invest.*, 16: 443, May, 1937.
[5] A. Emmerie, *Biochem. Jour.*, 28: 268, 1934.

Dr. W. H. Bradley, senior geologist, U. S. Geological Survey, likes the word "sapropol" previously suggested by H. Potomie in 1908.

Dr. Glover M. Allen, Cambridge, Mass., suggested "ilyonic food."

Dr. Denis L. Fox, Scripps Institution, La Jolla, Calif., likes "ilytrophic food"—from *ilytrophon* (mud food).

Dr. L. O. Shapolano, of Stanford University, would qualify "benthotic food" as littoral, sub-littoral, profundal and abysmal benthotic. Dr. Wm. Rienhoff, Sr., also suggested the necessity of qualifying the term benthotic according to depth.

Dr. Agnes De Sales, College of Mount St. Joseph on the Ohio, suggests "acropelotic"—*akros*, top; *pelos*, mud.

Dr. A. Willey, Mille Isles, Quebec, agrees with Dr. Glover M. Allen—"ilyonic food" to compare with planktonic food.

My own choice would lie between "ascion," suggested by Dr. Rienhoff, and "sapropol," suggested by Dr. Bradley.

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SPECIAL ARTICLES

A CRYSTALLINE PROTEIN WITH HIGH LACTOGENIC ACTIVITY*

DURING the course of chemical studies of anterior lobe fractions of the pituitary gland, it has been possible to isolate in crystalline form a protein having marked prolactin (lactogenic) activity. The method of preparation of the prolactin fraction from the gland is essentially that described by Lyons.[1] The purified prolactin preparations have been obtained in crystalline form from pyridine-acetic acid mixtures, using a procedure which is essentially the same as one employed for the crystallization of insulin.[2] One hundred milligrams of the purified fraction are dissolved in a centrifuge tube by the addition of 2 cc of 13 per cent. acetic acid. The material dissolves slowly. When solution is complete, 2 cc of 10 per cent. pyridine are added and the mixture centrifuged. The supernatant fluid, which is usually slightly turbid, is set aside and the precipitate dissolved in 2 cc of acetic acid and 2 cc of pyridine solution added as before; the mixture is then centrifuged. This procedure is repeated 10 times. The mother liquors are combined, and from this solution a crystalline precipitate can usually be obtained in either one of two ways: (1) The pyridine-acetic acid solution slowly deposits a crystalline material on standing for several days in the ice-box; (2) the pyridine-acetic acid solution is treated carefully with one per cent. ammonium hydroxide solution. The latter is added until a distinct, heavy turbidity results. Any material settling out immediately is centrifuged off and the turbid mother liquor placed in the ice-box over night. Microscopically, the crystals appear for the most part as cylindrical rods of varying length, with the rounded edges usually characteristic of protein crystals. The precipitate may be prepared in dry form by centrifuging, and washing at the centrifuge twice with 2 cc portions of ice-cold water, followed by washing once with a mixture of equal parts of absolute alcohol and dry ether, and finally washing two times with dry ether. It is dried in a vacuum desiccator over sulfuric acid.

In recrystallization the material may be treated exactly as described above by means of the pyridine-acetic acid procedure. The lactogenic activities of the various crystalline fractions and residues were determined by bioassays on one-month-old squabs, using the 2-day "local" test.[3] Some of the data obtained are shown in Table I.

TABLE I

ASSAY OF CRYSTALLINE PROLACTIN PREPARATIONS BY THE "LOCAL" OR INTRADERMAL TEST

Preparation	Crystallized	Extinction point*
A	Once	< 0.25 gamma
A	Twice	< 0.125 "
A	Thrice	0.0625 "
B	Once	< 0.25 "
B	Twice	< 0.125 "
C	Once	0.10 "
C	Twice	< 0.0625 "

* The extinction point is designated as the dosage below which a positive response to the injection can not be detected.

It will be seen from the data in Table I that after two recrystallizations, the preparations attain a fairly constant level at which a positive reaction is still obtained, *i.e.*, between one tenth and one twentieth of a gamma. When tested by the "systemic" test,[4] these preparations were found to have an average minimal effective dose of 0.1 mg. It is interesting to note how closely the results of the bioassays agree with the activities reported by Lyons recently[1] for his purified mammotropic hormone. It is evident that the latter investigator has a preparation of a high degree of purity.

A study of the x-ray diffraction pattern of the once crystallized product was kindly conducted by Professor L. W. McKeehan, director of the Sloane Physi-

* This study was made possible by a grant from the Fluid Research Fund of Yale University School of Medicine.

[1] W. R. Lyons, *Proc. Soc. Exp. Biol. and Med.*, 35: 654, 1936–37.

[2] V. du Vigneaud, H. Jensen and O. Wintersteiner, *Jour. Pharm. Exp. Ther.*, 32: 367, 1927–28.

[3] W. R. Lyons and E. Page, *Proc. Soc. Exp. Biol. and Med.*, 32: 1049, 1935.

[4] O. Riddle, R. W. Bates and S. W. Dykshorn, *Jour. Physiol.*, 105: 191, 1933.

Laboratory of this university. The powder method was used, employing copper Kα radiation with an exposure time of 18 hours and a plate distance of 6 cm. The diffraction pattern obtained is similar to those described in studies of the x-ray diffraction patterns of crystalline proteins. At least 4 sharp diffraction lines are visible: two of strong intensity at 88.5 A° and 43 A°, and two of weaker intensity at 39.3 A° and 29.8 A°. Although the x-ray diffraction pattern is typically that of a crystalline protein, it is recognized that the possibility of the presence of some amorphous material is not excluded on the basis of the x-ray study. Furthermore, the recent observations of Bernal and Fankuchen[5] may contribute some doubt to conclusions regarding the crystalline nature of a protein, based entirely on x-ray diffraction pattern studies.

The crystalline preparations behave like a protein in their color and precipitation reactions. Positive reactions are obtained with the biuret and xanthoproteic tests. The Millon's and the Hopkins-Cole reactions are also positive, as is the labile sulfur test. It has been reported[6] that purified prolactin preparations do not give the Millon's reaction, the xanthoproteic test or the labile sulfur test. This negative labile sulfur finding is particularly difficult to interpret in view of the fact that the same investigator reported cystine to be present in rather large amount (3.5 per cent.). The crystalline preparations are quite hygroscopic, and for micro-analysis were dried in the Pregl micro desiccator in partial vacuum in a slow stream of dry air. The following elemental composition was obtained:[7] *Carbon,* 51.11 per cent.; *hydrogen,* 6.76 per cent.; *nitrogen,* 14.38 per cent.; *sulfur,* 1.77 per cent.

The material gave no appreciable ash on ignition. The qualitative test for phosphorus was negative. A recent publication has reported[8] the presence of the latter element in purified prolactin preparations.

It is not possible at the present time to state definitely whether the crystalline protein which has been obtained is identical with the lactogenic hormone of the anterior pituitary gland, even though the evidence at hand at present would seem to indicate this conclusion. In view of the highly active, non-crystalline preparations of other investigators,[1] the discrepancies existing with respect to certain of the qualitative tests[6, 8] and the interpretation placed by Bernal and Fankuchen[5] on x-ray diffraction pattern studies, it seems best to report the present findings for purposes of record rather than of deduction. Investigations are being continued to determine whether the crystalline protein exhibits any other type of physiological activity which has been attributed to anterior pituitary extracts. Preliminary studies of the purified, non-crystalline fractions demonstrate that this material, injected at a 4 mg level daily into hypophysectomized rats, does not stimulate growth.

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[5] J. D. Bernal and I. Fankuchen, *Nature,* 139: 923, 1937.

[6] E. I. Evans, *Am. Jour. Physiol.,* 119: 303, 1937.

[7] The micro-analyses were conducted by Mr. W. Saschek, of Columbia University, using the micro-Pregl procedures.

[8] W. H. McShan and H. E. French, *Jour. Biol. Chem.,* 117: 111, 1937.

THE PROTECTIVE ACTION OF CERTAIN PURINES AGAINST LIVER NECROSIS PRODUCED BY CARBON TETRACHLORIDE AND CHLOROFORM

NUMEROUS investigators have reported the occurrence of liver necrosis following the administration of carbon tetrachloride or chloroform. Many experiments have been performed in an attempt to determine the effects of changes in dietary constituents upon the histopathologic liver changes resulting from the administration of these liver poisons. Recently, Forbes and Neale[1] and Forbes, Neale and Scherer[2] reported the preparation of a liquid fractional extract of hog livers which, when administered to albino rats prior to acute poisoning with chloroform or carbon tetrachloride, exerted a protective action against these drugs. This extract contained an unknown number of substances. The detoxicating activity of the solution was found not to be due to choline or glucose content. From their solution, Forbes and McConnell[3] succeeded in preparing a crystalline substance which, in 50 to 100 mg doses given subcutaneously to rats prior to carbon tetrachloride poisoning, protected the animals from liver necrosis.

In this laboratory qualitative analysis of the crystalline substance which protected the animals showed the major portion of the product to be of a purine nature. The purine substance was separated from the other substances present and purified. This procedure did not alter the protective activity. The results of quantitative analyses for carbon, hydrogen, nitrogen and sodium indicated the empirical formula, $C_5N_4H_3O_2Na$. Further analyses and qualitative tests indicated that this substance is mono-sodium-2,6-dioxy-purine, sodium xanthine.

Hence, sodium xanthine was next prepared from

[1] J. C. Forbes and R. C. Neale, *Proc. Soc. Exper. Biol. and Med.,* 34: 319, 1936.

[2] J. C. Forbes, R. C. Neale and J. H. Scherer, *Jour. Phar. and Exper. Therap.,* 58: 402, 1936.

[3] J. C. Forbes and Jeannette McConnell, *Proc. Soc. Exper. Biol. and Med.* In press.

commercial xanthine, purified in this laboratory and injected subcutaneously into rats in the same quantities as the crystalline preparation from liver. Rats receiving 100 mg of sodium xanthine 20 hours before acute carbon tetrachloride poisoning by deep anesthesia for one hour and forty minutes, suffered only a slight fatty infiltration of their livers with a very limited round cell infiltration around the central veins. Ninety per cent. of the control rats, subjected to the same poisoning, died within 48 hours following the anesthesia, and after the expiration of that time the surviving rats were killed. Microscopic examinations showed very nearly complete destruction of the liver in practically all the control animals. The protection with mono-sodium-2,6-dioxy-purine was the same as that found with the crystalline preparation from liver.

Sodium guanine, injected into rats in doses of from 50 to 100 mg, exerted the same protective action as did the sodium xanthine and the preparation from liver. Adenine sulfate given in equivalent doses protected the animals to a certain extent but seemed to be definitely toxic itself in the amounts injected. Further experiments using chloroform poisoning showed both sodium guanine and sodium xanthine to protect the livers of rats. Liver sections from animals protected with these substances and subjected to two hours of deep chloroform anesthesia showed no histological changes except for an infiltration of a few fibroblasts intercellularly. There was no fatty infiltration or degeneration. Sections of the livers of control animals exhibited typical central necrosis extending toward the periphery of the lobule involving 50 per cent. of the liver lobule. Many of the control animals died.

Other purine bases and derivatives, both natural and synthetic, are being tested for protective action against carbon tetrachloride, chloroform and other liver poisons. A more complete report will appear in the near future, giving complete chemical identification of the active crystalline substance from liver and showing the effects of purines on the toxicity of the more common poisons.

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CORTICO-ADRENAL AND NEURAL EFFECTS ON GONADOTROPIC ACTIVITY OF THE PITUITARY[1]

IN the rabbit and cat ovulation usually occurs only after mating and is dependent upon the secretion of the anterior hypophyseal gonadotropic hormones. The data recently published by Brooks[2] and by Haterius and Derbyshire[3] suggest that in the rabbit coitus stimulates the pituitary through nerves in the infundibular stalk. Previously, only one neural pathway to the cells of the anterior hypophysis was recognized, *viz.*, the cervical sympathetic fibers.

In 1935, Friedgood and Pincus[4] and Friedgood and Cannon[5] stimulated electrically the cervical sympathetics of normal estrous rabbits. Such stimulation resulted in ovum maturation in the majority of rabbits, but rarely did it result in ovulation, and then only of a limited number of ova. The simultaneous intravenous injection of adrenalin did not enhance the effect of these electrical stimuli. Quantitatively, therefore, the ovarian response was similar to that evoked by injections of subovulatory doses of FSH and LH. It was concluded that stimulation of the pituitary through its sympathetic innervation increased, to a limited extent only, the normal rate of secretion of its gonadotropic hormones. Collin and Hennequin[6] later reported that stimulation of these nerves resulted in marked cytological changes in the anterior pituitary.

In searching for another factor which might influence the rate of secretion of the gonadotropic pituitary hormones, the possibility of a humoral mechanism was considered. The cat was used as an experimental animal, instead of the rabbit, because its survival period after adrenalectomy is longer. Estrous cats go out of heat and their ovaries atrophy after bilateral adrenalectomy, even if the animals are maintained in apparent good health by daily administration of a potent preparation of cortin[7] containing the life-sustaining hormone. A preliminary unilateral adrenalectomy was therefore carried out on 12 anestrous cats. After objective evidence of the estrous state developed in these animals (4 to 12 weeks later), 9 of them were subjected to a second adrenalectomy from 15 to 55 minutes after mating. This procedure prevented the occurrence of ovulation in every instance. In the remaining 3 cats, adrenalectomy was delayed until 6 hours postcoitum. All 3 animals ovulated. These experiments indicate either that adrenalectomy within one hour after mating interferes with the usual response of the anterior hypophysis to the coital stimulus, or that the ovary is unable to respond normally to

[1] From the Department of Physiology in the Harvard Medical School, Boston. Aided by a grant from the National Research Council Committee for Research in Problems of Sex.

[2] C. McC. Brooks, *Proc. Am. Physiol. Soc.* In press.
[3] H. O. Haterius and A. J. Derbyshire, *ibid.* In press.
[4] H. B. Friedgood and G. Pincus, *Endocrinology*, 19: *Physiol.*, 116: 54, 1936.
[5] H. B. Friedgood and W. B. Cannon, *Am. Jour. Physiol.*, 116: 54, 1936.
[6] R. Collin and L. Hennequin, *Compt. rend. Soc. de biol.*, 121: 84, 1936.
[7] We are indebted to Dr. David Klein, of the Wilson Laboratories, who furnished the cortico-adrenal extract for these experiments.

these hormones if the adrenals are removed so early in the experiment. In order to decide this point, another series of observations was carried out with the collaboration of Dr. M. A. Foster.[8]

The ovaries of anestrous cats can be stimulated experimentally[9] by the proper administration of the gonadotropic hormones FSH and LH. Adrenalectomy at various intervals prior to the injection of FSH and LH did not prevent ovulation and subsequent luteinization, although they were retarded beyond the normal period of about 36 hours for as long as 10 to 22 hours; and huge cysts, lined by somewhat atypical lutein cells, were found in the ovaries of those adrenalectomized cats which were autopsied more than 50 hours after the last injection. The injection of FSH and LH into normal control cats has not in our experience resulted in the development of these remarkable cystic structures.

One may conclude, therefore, that the adrenal glands are essential for the proper coital stimulation of the anterior pituitary. Even if coitus in the cat activates the anterior pituitary through nerves in the infundibular stalk (as Brooks suggests for the rabbit), these stimuli are ineffective in the absence of the adrenals. It may be inferred also that it is the cortex of the adrenal which contains the gonadotropic hormone, since the distribution of the splanchnic nerves is limited to the adrenal medulla, and adrenalin, in our experience, has not induced ovulation.

The anterior pituitary of the cat is similar to that of the rabbit[10,11] in that it does not secrete enough gonadotropic hormone during the first hour after mating to induce ovulation. The time which elapses between the coital act and the gonadotropic response of the pituitary is, at least in part, consumed in the secretion (and perhaps elaboration) of an adrenal cortical hormone. This humoral substance is capable of stimulating or of cooperating in the stimulation of the gonadotropic activity of the anterior pituitary. This explanation accounts satisfactorily for the fact that ovulation is not prevented by adrenalectomy if the operation is delayed until 6 hours postcoitum. Sometime within this period, the anterior hypophysis secretes its gonadotropic hormones with the cooperation of the adrenal glands.

HARRY B. FRIEDGOOD

SCIENTIFIC APPARATUS AND LABORATORY METHODS

GLYCYLGLYCINE AS A SEA WATER BUFFER[1]

IT is necessary in many experiments with marine eggs to remove the carbonate components of the sea water, which normally acts as its principal buffer system,[2] and to substitute some suitable buffer. The buffer chosen must, of course, have its dissociation index in about the middle of the pH range in which it is desired to work and, above all, it must have no injurious effects on the living material in the concentrations it is necessary to employ. We find that the dipeptide, glycylglycine, may be used as a satisfactory buffer between pH 7 and 9. Phosphate, which is perhaps the most commonly used buffer, is about the only other agent that has been used[3] in carbonate-free sea water with marine eggs. It is, however, useful only at low pH. At higher pH's it precipitates out the Ca and Mg of the sea water. For example, carbonate-free sea water containing phosphate at a total concentration of 0.01 molar will start to precipitate at pH 6.3, and when the pH is raised to 8.0, more than 95 per cent. of the Ca and the Mg of the sea water is lost. Developing eggs have long been known to be peculiarly affected by Ca or Mg lack.[4] Egg albumen or gelatin, which would buffer over a wide pH range, block cleavage in low concentrations.

Glycylglycine has the appropriate dissociation constant and has sufficient solubility in sea water for buffering around pH 8.0. Recent values of its pK′ (amino) are given as 8.07,[5] 8.80 (0° C.),[6] 8.13 (25° C.),[6] 8.86 (0° C.),[7] 8.17 (25° C.).[7] In sea water the value would be affected by the ionic strength. In Fig. 1, a titration curve (glass electrode) for 0.025 molar glycylglycine in carbonate-free sea water is given. From this we get a pK′ of 8.1 (18.5° C.).

The effect on development was examined by placing freshly fertilized sea-urchin eggs in carbonate-free sea water containing various concentrations of glycylglycine.[8] The solutions were all adjusted to the same pH

[8] H. B. Friedgood and M. A. Foster, *Proc. Am. Physiol. Soc.* In press.

[9] M. A. Foster and F. L. Hisaw, *Anat. Rec.*, 62: 75, 1935.

[1] From the William G. Kerckhoff Laboratories of the Biological Sciences, California Institute of Technology, Pasadena, Calif.

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[8] The analytically pure glycylglycine supplied by the

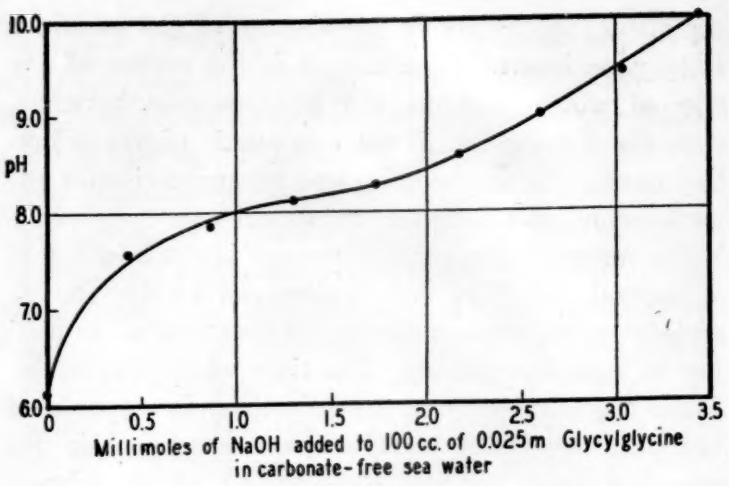

FIG. 1

and were made isosmotic with sea water. Even in the highest concentrations that we employed, namely, 0.25 molar glycylglycine at pH 8.2, cleavage was 100 per cent. Later development is, however, distinctly abnormal in the solutions stronger than 0.10 molar. Between 0.05 and 0.10 molar there is an apparent effect of the glycylglycine in producing thick-walled blastulae and gastrulae. Below 0.05 molar, there is no evidence of any particular effect. For most purposes (*e.g.*, respiration experiments) a 0.005 to 0.02 molar solution provides sufficient buffer action. Veronal[9] which was tried, since it has also a pH of 8.0, causes abnormal development in a concentration of 0.002 molar; although cleavage may proceed in a 0.01 molar solution.

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UNIVERSAL JOINTS FOR SKELETONS

SEVERAL attempts have been made to produce a mechanical joint for mounted skeletons that would permit motion in all three planes. A joint mechanism was sought that would give movements similar to those observed in a living body, yet without being so large as to be cumbersome nor so flimsy as to be unable to withstand the rigorous handling of freshman medical students.

Fig. 1 shows a joint mechanism that has been successful in three years of service in the medical school laboratory. Twelve of these devices are in good working order on the laboratory skeletons. In the sketch in Fig. 1 is seen a wrist joint assembled in such a fashion as to allow flexion and extension of the hand as well as abduction and adduction. Pronation and supination are obtained by a device modeled after one which has been used by others.

Abduction and adduction are obtained by a sliding joint, which is seen dissembled in Fig. 2. The part A has two rivets which fit into slots in the part B and

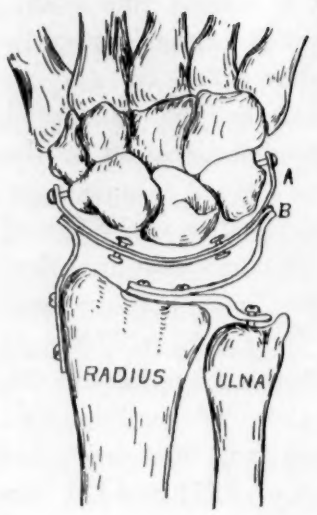

FIG. 1

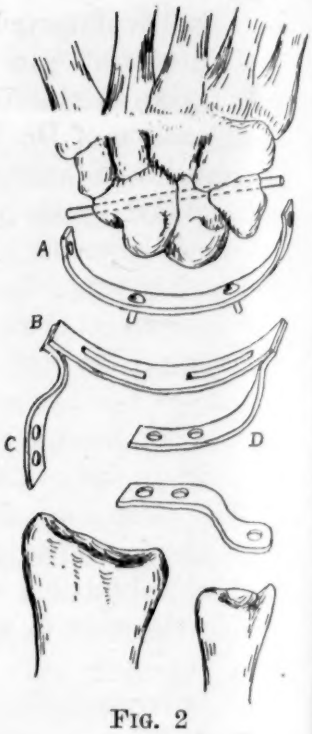

FIG. 2

their ends are headed to hold them in the slots. The length of the two slots can be varied, depending upon the amount of abduction desired. The part B is held stationary to the radius bone by the parts C and D, which are attached to the bone by small brass screws. B is attached to C and D by solder. Such a device allows the part A, which is attached to the hand, to slide back and forth upon the part B and simulate the abduction and adduction of the living hand.

The part A is attached to the carpal bones of the hand by an axle or pin passing through the proximal three carpal bones, as seen by the dotted line in Fig. 2. The ends of the pin are inserted into the holes in the metal piece A, and these ends are flattened to prevent them from pulling out of the holes. A complete flexion or extension of the hand can thus be obtained, as the pin through the carpus acts similarly to an axle.

The same method was utilized in a joint for the shoulder to obtain medial and lateral rotation of the arm as well as flexion and extension, and abduction and adduction.

The parts used in this joint can be made of sheet brass or of any durable iron alloy in bands about one thirty-second of an inch in thickness.

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Amino Acid Manufactures, of the University of California at Los Angeles, was used in these experiments.

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